



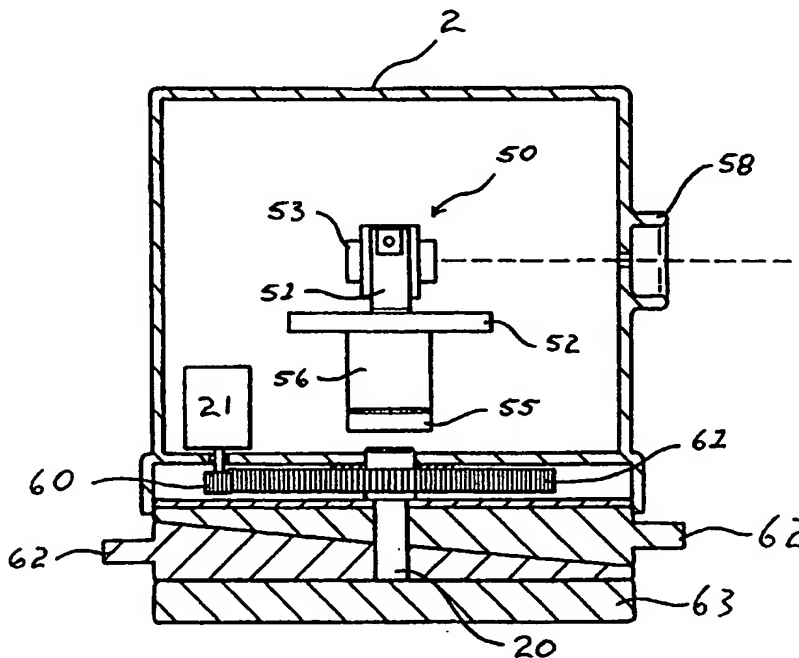
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : G01C 1/00, 3/00, 5/00, 9/00, 15/00	A1	(11) International Publication Number: WO 96/01978
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<p>(21) International Application Number: PCT/AU95/00411</p> <p>(22) International Filing Date: 7 July 1995 (07.07.95)</p> <p>(30) Priority Data: PM 6733 8 July 1994 (08.07.94) AU</p> <p>(71)(72) Applicant and Inventor: CONNOLLY, Michael [AU/AU]; 24 Grenfell Street, Kent Town, S.A. 5067 (AU).</p> <p>(74) Agent: HORSBURGH, Mark, A.; Fisher &amp; Kelly, 1/349 Coronation Drive, Milton, QLD 4064 (AU).</p>		<p>(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).</p> <p>Published With international search report.</p>

(54) Title: REMOTELY OPERATED LEVELLING DEVICE

## (57) Abstract

A remotely operated device by which a single user can perform measurement or levelling tasks comprises an automatically levelling laser beam emitting unit (53) that can be remotely manoeuvred. The laser unit (53) is mounted in a body (50) which is mounted on a rotating base (53). A remote control means transmits signals to a manoeuvring means (21, 60, 61, 62) that controls the rotation of the base (52). A user sets up the device in a central location and moves to a location which must be measured. Using the remote control the laser beam is manoeuvred until directed towards the user and various measurements of height and direction can be made.



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## TITLE

## REMOTELY OPERATED LEVELLING DEVICE

5 This invention relates to surveying and building equipment and in particular to remotely operated devices which permit most surveying, building or construction tasks to be performed by a single person.

## FIELD OF THE INVENTION

10 There is a need to obtain comparative height, distance and level information in most building and construction tasks. A number of optical tools exist to perform the required functions. Theodolites are used to measure horizontal or vertical angles and dumpys are used for obtaining an automatic level. Microwave and laser based devices are available for measuring  
15 distance.

Since about the early 1970's laser-based levelling tools have been available which provide an infrared or visible reference. The laser levelling tools have increased in sophistication and found broader application in recent years.

20 One early laser level and squaring tool was disclosed in United States patent number 3897637. This device utilised a helium-neon laser which projected a vertical and horizontal beam. The device needed to be manually levelled.

A later patent, United States patent number 4221483, discloses a  
25 laser levelling device which provides for automatic levelling of a vertical beam within a small range of tilt. This is achieved by mounting a collimating lens on a pendulum so that the beam remains vertical as long as the tilt of the instrument is within the range of the pendulum.

A compact device for establishing a precise level, a plumb line or  
30 an alignment line is described in United States patent number 4912851 assigned to Spectra-Physics Inc. This device is based upon a laser diode and

includes tilt compensation which allows the device to be used on surfaces up to 5° off level.

The primary advantage of the above mentioned devices is that they project a collimated, visible beam which can be used for alignment. Many  
5 provide automatic levelling.

Most of the prior art devices known to the inventor require two person operation to perform surveying tasks in building and construction. One exception is a rotating laser which has a rotating laser head which sweeps a laser beam in a horizontal plane. The device is used in conjunction with a  
10 receiver that indicates the direction the receiver needs to move to be centred on the beam. The device is typically used with earth moving equipment to grade or check a level site, by concreters when laying a floor or foundation and by other tradesmen for a variety of applications requiring level.

To lay out a building site, whether using a conventional theodolite, dumpy level requires one person at the device and another person to move  
15 around the site with a staff. With a theodolite or automatic (dumpy) level the person at the device focuses on the staff and reads off the height, thus building up a profile of the site by repeated measurement.

Distance measurement also requires two person operation whether  
20 using conventional measuring means or modern electronic devices.

A single person can profile a site but repeated movement between the measurement device and the staff is required. This is time consuming and distracting. A remotely operated device that can be operated by a single person is desirable.

25

## BACKGROUND OF THE INVENTION

One object of the present invention is to provide a remotely operated device which can be used by a single person to perform many  
30 surveying, building or construction tasks.

Another object of the invention is to offer the public a useful alternative to existing levelling and measuring equipment.

## SUMMARY OF THE INVENTION

In one form, although not necessarily the only or indeed the broadest form, the invention resides in a remotely operated device for performing measurement or levelling tasks comprising:

measurement means adapted to measure one or more of distance, direction, height or angle;

manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

wherein a user can remotely manoeuvre the measurement means to be directed at a desired location thereby facilitating single user performance of measurement or levelling tasks.

In preference the measurement means may be a conventional dumpy level, theodolite, laser level, range finder (microwave or infrared) or similar measuring device used in the building, construction or surveying industries.

The receiving means is preferably an optical, ultrasonic or infrared receiver/decoder and the remote control means preferably comprises an optical, ultrasonic, microwave or infrared transmitting means and coding means. The transmitting means transmits a coded signal to the receding means which receives and decodes the signal. The manoeuvring means responds to the decoded signal to appropriately position the measurement means.

In an alternative arrangement the remote control means and manoeuvring means comprise an automatic tracking means in which the remote control means is associated with a staff and sends signals which are tracked by the receiving means of the manoeuvring means. In this arrangement the user simply moves around a site with the staff and the measurement means automatically follows and remains directed at the staff.

The automatic tracking means may also comprise a reflector on the staff with transmitting and receiving means associated with the manoeuvring

means.

It will be appreciated that an advantage of the invention is that the manoeuvring means could be fitted as an accessory to existing measurement devices.

5 In a further form, although again not necessarily the only or indeed the broadest form, the invention resides in a remotely operated levelling device comprising:

a light beam emitting means adapted to emit a beam of collimated light;

10 said light beam emitting means being mounted on a rotatable base; wherein the rotatable base rotates in response to signals received from a remote control unit.

In preference the light beam emitting means is a laser diode which may include a collimating lens. In the simplest form the light beam emitting  
15 means may be a vial laser level comprising a laser diode aligned to a vial such as contained in a conventional bubble level.

In preference the invention further comprises an optical arrangement adapted to automatically maintain the beam in a horizontal plane. The laser levelling device may further comprise a penta prism adapted to  
20 optionally deflect the beam, or a part of the beam, through 90 degrees to produce a vertical and horizontal beam or two orthogonal horizontal beams.

The optical arrangement preferably comprises a pendulous mirror adapted to reflect the laser beam to a deflecting mirror which deflects the beam through an exit port of the device. The pendulous mirror is preferably damped  
25 by magnetic damping means or air damping means.

There is preferably a focussing means at the exit port adapted to focus the beam to a spot at varying distances from the device. The focussing means is preferably controllable by the remote control means.

A person can survey a site by locating the device at the centre of  
30 the site and moving around the site with a staff and the remote control unit. The person uses the remote control unit to rotate the laser beam until it is detected on the staff. The beam may then be focussed (if required) using the

remote control to provide a small visible mark such as a spot or line on the staff from which a measurement can be read. (For distances up to about 30 metres no focussing of the laser beam is required, beyond this distance the divergence of the beam is such that focussing may be required to maintain accuracy.)

5 Alternatively, an electronic indicator may be employed to detect the laser beam and provide a digital readout of its location. The electronic indicator may be configured to give an indication (such as left/right/up/down LED's) of the direction of the laser beam away from centre. Electronic indicators of the type described are commercially available and will be known  
10 to persons skilled in the art.

### BRIEF DESCRIPTION OF THE DRAWINGS

To further assist in understanding the invention reference will be  
15 made to the following drawings in which:

FIG 1 shows a schematic of a first embodiment of a laser levelling device;

FIG 2 shows a remote control for use with the laser levelling device;

20 FIG 3 depicts the use of the laser levelling device by a single person;

FIG 4 shows a schematic of a second embodiment of a laser levelling device;

FIG 5 shows an isometric view of a portion of the device of FIG 4;

25 FIG 6 shows a third embodiment of a portion of a laser levelling device; and

FIG 7 shows a schematic block circuit diagram for the remote control of the laser levelling device of any of the embodiments.

## DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in detail there is shown in FIG 1 a laser levelling device generally indicated as 1. The device comprises a body 2 housing, a laser diode 3 and an optical arrangement. The laser diode is a visible laser diode operating at around 635 nm (red). The power supply for the laser diode is DC and may be an appropriate number of batteries. Alternatively the DC power supply can be separately contained and connected to the laser levelling device by a power cable.

The optical arrangement comprises a pendulous mirror 4 mounted on a platform 5 suspended within the body by thin flexible wires 6. The thin wires allow the platform to swing freely so as to adopt a horizontal position even when the body 2 is not perfectly level. The pendulum arrangement will permit displacements of the body of up to one degree from horizontal.

A laser beam 7 emitted from the laser diode 3 is reflected by the pendulous mirror 4 to a deflecting mirror 8 which directs the beam through an exit port 9. The pendulous mirror 4 and deflecting mirror 8 together form the optical arrangement.

Damping magnet 13 acts on platform 5 (which is made of ferromagnetic material) with an attractive magnetic force thereby providing a damping force to minimise the time necessary for the mirror to come to rest. Magnetic damping of the pendulum's kinetic energy is conventionally employed in theodolites, dumpys and the like.

An alternative form of damping which would be known to those skilled in the art is air. Air damping employs a piston and cylinder arrangement to trap a small amount of air which is allowed to leak slowly from the cylinder. One half of the arrangement is attached to a fixed base and the other to the platform to be damped. The trapped air acts to limit the movement of the platform at the extremities of its motion. Although the figures only depict magnetic damping means it will be clear to those skilled in the art that air damping or other damping techniques could also be employed.

The optical arrangement of the preferred embodiment is quite

simple. A more complex optical arrangement can be employed for greater precision. An optical arrangement from a conventional dumpy level can be used but with the eye-piece optic being replaced by a laser diode. A conventional dumpy level has an optical arrangement which automatically  
5 aligns the view of an operator to the horizontal when the dumpy is coarse aligned to within about 20 minutes of arc of level. A collimated beam from a laser diode directed into the eye-piece of the dumpy will be emitted horizontal under the same conditions.

A telescope 10 is coupled to the exit port 9 of the body 2. The  
10 telescope comprises a fixed lens 11 and an adjustable lens 12. The position of the lens 12 relative to the fixed lens 11 is adjustable to change the focal length of the beam emitted from the exit port 9. The lens 12 is coupled to an adjustment means (not shown) which adjusts the position of the lens in response to signals received from a remote control 30. The adjustment means  
15 may be conventional pulley system or a rack and pinion arrangement.

The body 2 is mounted on a tilt base comprising a fixed plate 15 and a floating plate 16. The floating plate 16 is held to the fixed plate 15 by a torsion bar 17. The angle of the floating plate 16 relative to the fixed plate 15 is adjusted by threaded adjusting screws 18. A centre bubble is provided on the  
20 floating plate to allow coarse levelling of the device to within the range of the automatic levelling provided by the optical arrangement.

The body 2 is free to rotate on axle 20 under the impulse of motor 21 coupled to a wheel 22 which runs against the body 2. To maintain stability of the body 2 a bearing track 23 is provided between the body 2 and the  
25 floating plate 16.

The motor 21 is preferably a DC stepping motor. As with the laser diode 3 the power supply for the motor 21 are batteries located in a battery pack close to the motor. Alternatively, the DC power supply may be located separately and connected to the motor by a power cable. The operation of the  
30 motor is controlled by the remote control unit 30.

A remote control unit 30 is shown in FIG 2. The unit transmits a coded signal which is decoded by receivers on the motor 21 and telescope 10.

## CLAIMS

1. A remotely operated device for performing measurement or levelling tasks comprising;  
5 measurement means adapted to measure one or more of distance, direction, height or angle;  
manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;  
wherein a user can remotely manoeuvre the measurement means,  
10 with the remote control means, to be directed at a desired location thereby facilitating single user performance of measurement or levelling tasks.
2. The device of claim 1 wherein the measurement means is a dumpy level, theodolite, range finder or other similar measuring device used in the building, construction or surveying industries.
- 15 3. The device of claim 1 wherein the measurement means is a laser levelling device;
4. The device of claim 3 wherein the laser levelling device comprises a laser diode emitting optical radiation in a beam, said beam being directed to an optical arrangement comprising a damped pendulous mirror mounted on a  
20 platform suspended by thin flexible wires, and a deflecting mirror positioned to direct the beam horizontally.
5. The device of claim 3 wherein the laser levelling device comprises a laser unit mounted within a support structure allowing rotation of the laser unit about a horizontal axis, there being a ferromagnetic pendulous weight  
25 extending below the laser unit such that when the pendulous weight is in its rest position a beam emitted from the laser unit will be horizontal, the device further comprising magnetic dampers disposed adjacent the ferromagnetic pendulous weight.
6. The device of claim 3 wherein the laser levelling device comprises  
30 a laser unit pivotally mounted in a frame and an electrolytic potentiometer mounted in the frame wherein the signal from the potentiometer controls a motor to adjust the angle of the laser unit relative to the horizontal.

7. The device of claim 1 wherein the receiving means is an optical, ultrasonic, microwave or radio frequency receiver/decoder and the remote control means comprises an optical, ultrasonic, microwave or radio frequency transmitting means and coding means.

5 8. The device of claim 1 wherein the user locates a staff at the desired location and the measurement means is directed at the staff by the user operating the remote control means.

9. The device of claim 8 wherein the staff includes electronic indicator means adapted to provide a visible and/audible indication to assist the user to  
10 direct the measurement means to be centred on the staff.

10. A remotely operated device for performing measurement or levelling tasks comprising:

measurement means adapted to measure one or more of distance, direction, height or angle;

15 manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

wherein the remote control means and manoeuvring means comprise an automatic tracking means in which the remote control means is associated with a staff and transmits signals which are tracked by the receiving  
20 means of the manoeuvring means such that the measuring means remains directed at the staff as a user moves the staff from one desired location to another.

11. A remotely operated device for performing measurement or levelling tasks comprising:

25 measuring means adapted to measure one or more of distance, direction, height or angle;

manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

30 wherein the remote control means and manoeuvring means are located with the measurement means and comprise an automatic tracking means and there is a reflector on a staff wherein signals transmitted from the remote control means are reflected by the reflector and received by the

manoeuvring means such that the laser levelling means tracks the staff as a user moves the staff from one desired location to another.

12. A remotely operated laser levelling device comprising:  
a light beam emitting means adapted to emit a beam of collimated  
5 visible light;  
said light beam emitting means being mounted on a rotatable base;  
wherein the rotatable base rotates in response to signals received  
from a remote control unit.

13. The device of claim 12 wherein the light beam emitting means is a  
10 laser diode incorporating a collimating lens.

14. The device of claim 12 wherein the light beam emitting means is a  
vial laser level comprising a laser diode aligned to a vial such as contained in a  
conventional bubble level.

15. The device of claim 12 wherein the laser levelling device  
comprises a laser diode emitting optical radiation in a beam, said beam being  
directed to an optical arrangement comprising a damped pendulous mirror  
mounted on a platform suspended by thin flexible wires, and a deflecting mirror  
positioned to direct the beam horizontally.

16. The device of claim 12 wherein the laser levelling device  
20 comprises a laser unit mounted within a support structure allowing rotation of  
the laser unit about a horizontal axis, there being a ferromagnetic pendulous  
weight extending below the laser unit such that when the pendulous weight is  
in it's rest position a beam emitted from the laser unit will be horizontal, the  
device further comprising magnetic dampers disposed adjacent the  
25 ferromagnetic pendulous weight.

17. The device of claim 12 wherein the laser levelling device  
comprises a laser unit pivotally mounted in a frame and an electrolytic  
potentiometer mounted in the frame wherein the signal from the potentiometer  
controls a motor to adjust the angle of the laser unit relative to the horizontal.

30 18. The device of claim 12 further comprising a penta prism adapted to  
optionally deflect the beam, or a part of the beam, through 90 degrees to  
produce two orthogonal beams.

19. The device of claim 12 further including a focussing means adapted to focus the beam to a spot at a varying distance from the device, said focussing, means being controllable by the remote control means.

1/3

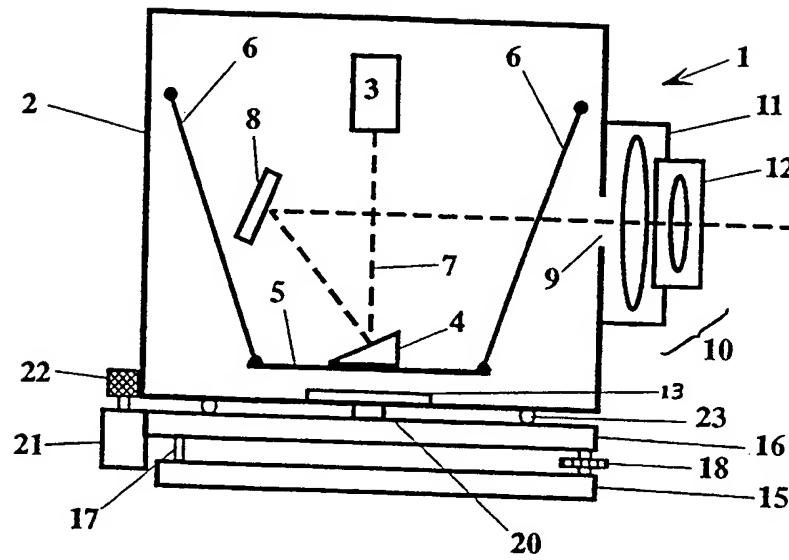


FIG 1

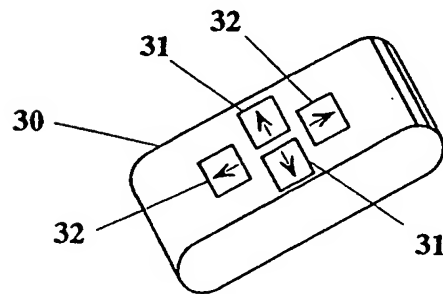


FIG 2

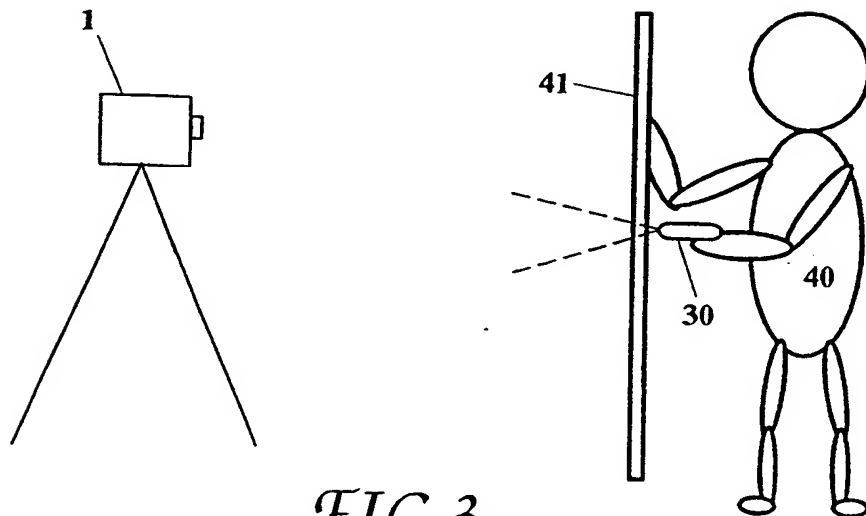
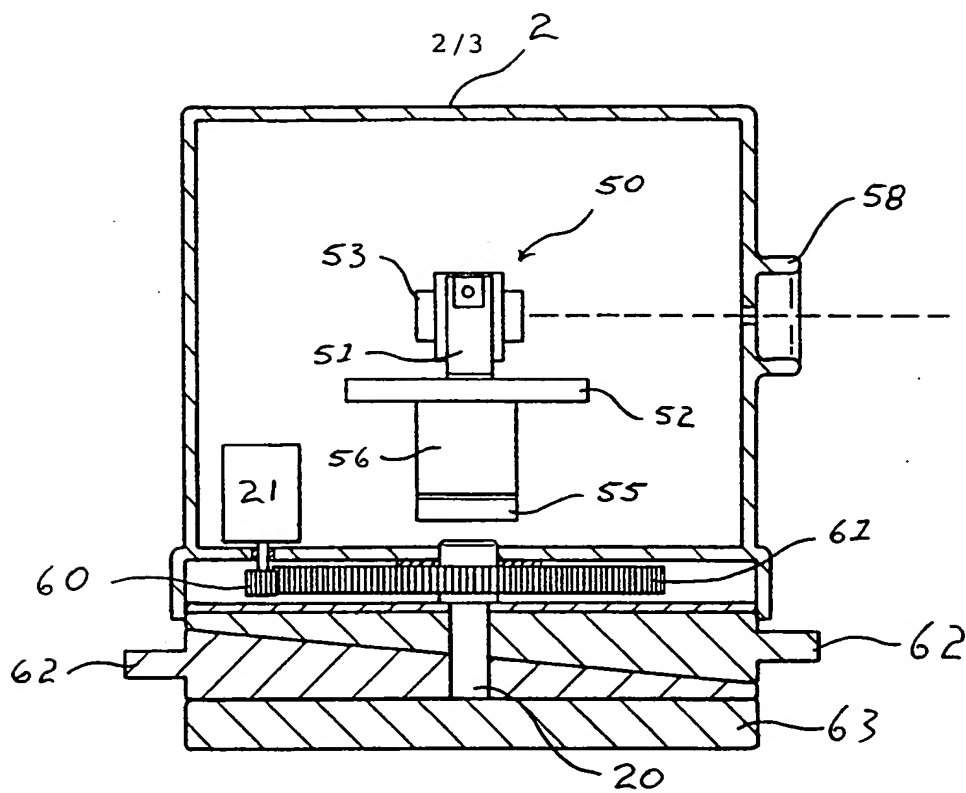
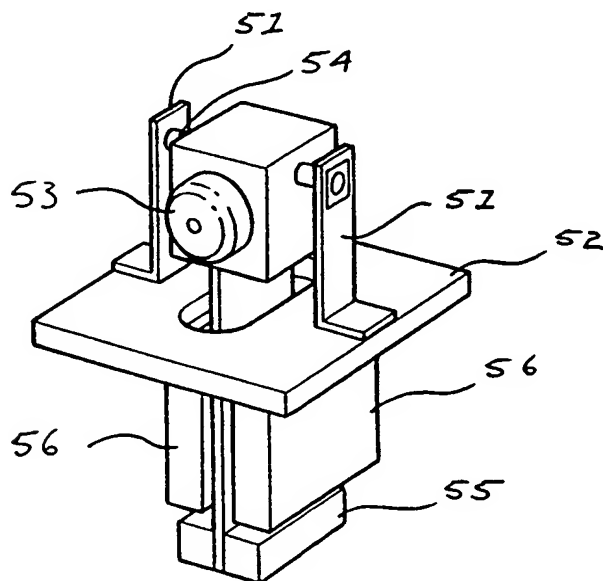


FIG 3

*FIG 4**FIG 5*

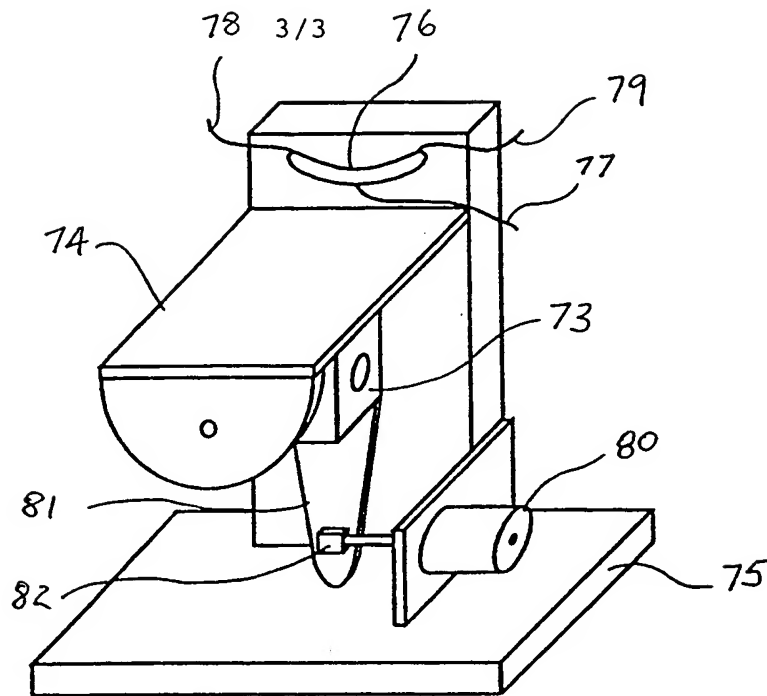


FIG 6

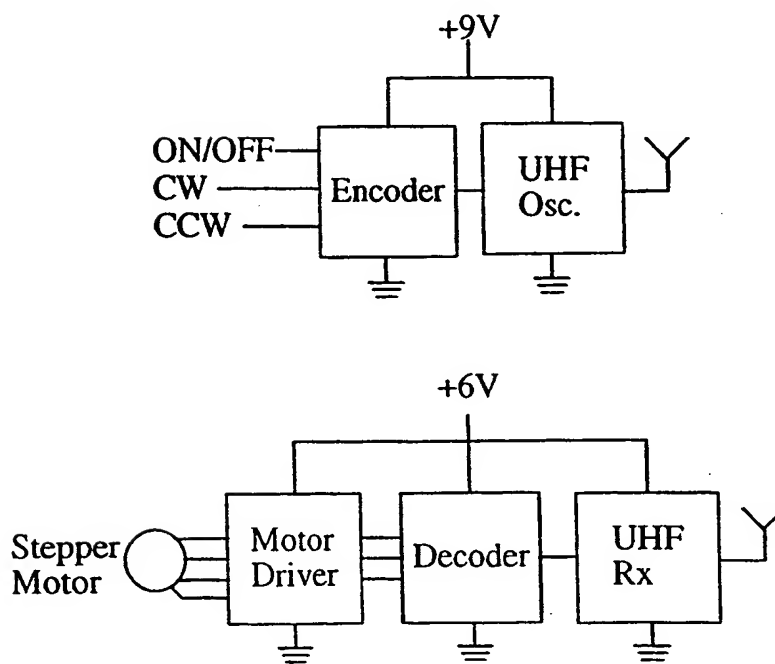


FIG 7

# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/AU 95/00411

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>				
Int Cl <sup>6</sup> : G01C 1/00, 3/00, 5/00, 9/00, 15/00 0				
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
Minimum documentation searched (classification system followed by classification symbols) IPC G01C 1/00, 3/00, 5/00, 9/00, 15/00				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU: as above				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Derwent: remote: Japio: remote:				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X	WO, 91/19165 A (PARKERVISION) 12 December 1991 see whole document	1,7		
X	WO, 92/20998 A (LASER LEVEL SWEDEN) 26 November 1992 see whole document	1, 2, 3, 7, 12, 13, 14, 18		
X	EP 0051913 A (DELKE) 19 May 1982	1, 2, 3, 7, 8, 9, 12		
<input type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex				
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Date of the actual completion of the international search 20 October 1995		Date of mailing of the international search report 20 OCTOBER 1995		
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (06) 285 3929		Authorized officer F. C. Pearson Telephone No.: (06) 283 2195		

**INTERNATIONAL SEARCH REPORT**

International Application No.

**PCT/AU 95/00411**

<b>C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>
X	US 4907879 A (WEBB) 13 March 1990	1, 2, 3, 7, 8, 9, 12

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International Application No.  
**PCT/AU 95/00411**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
WO	9119165 A	AU	81909/91	CA	2084201 A	EP	532694 A
		US	5268734 A	US	5432597 A		
WO	9220998 A	AU	17801/92	SE	9101525		
EP	51913 A	JP	57080515	US	4413907		
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